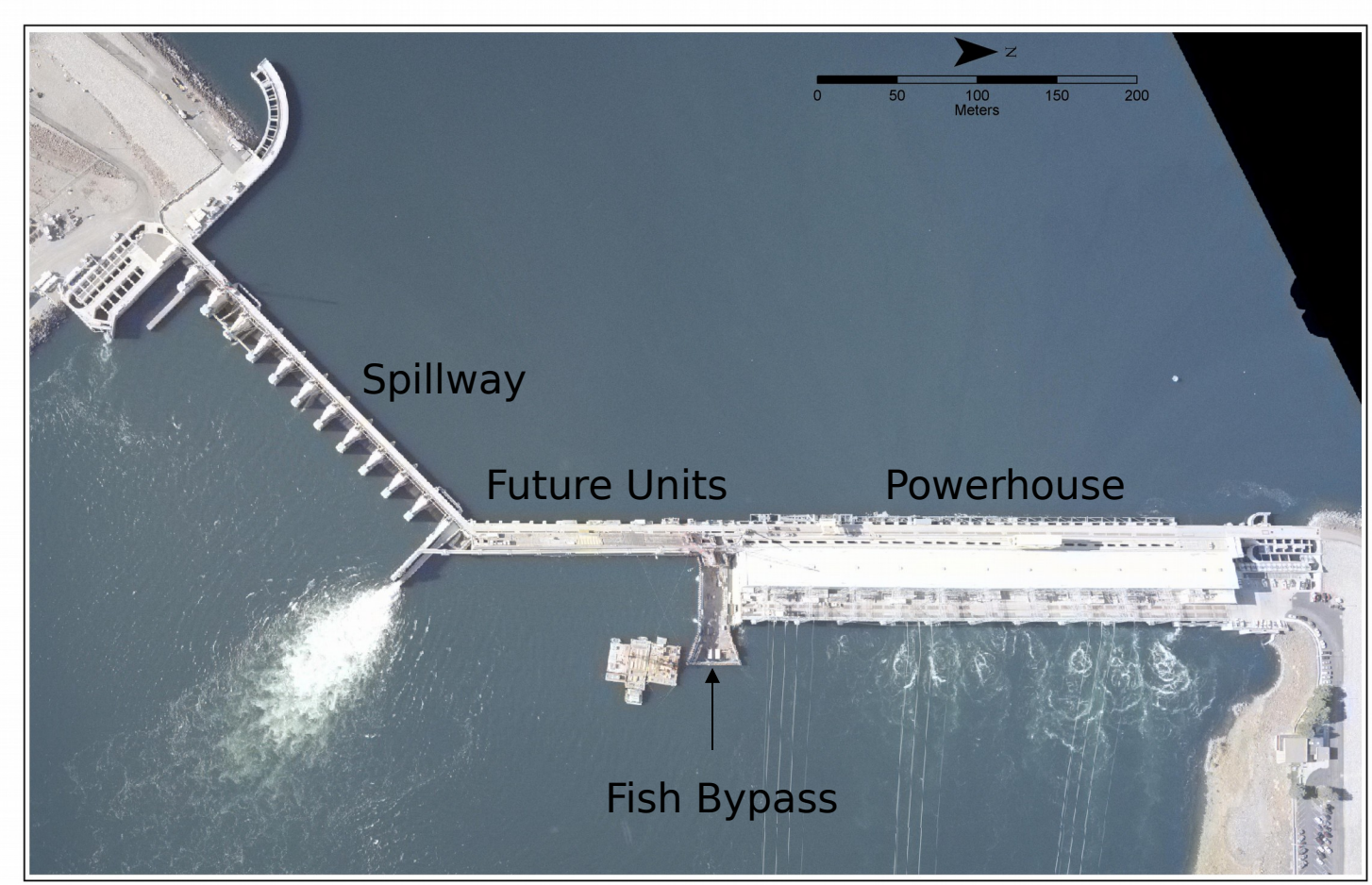
Wanapum Dam Total Dissolved Gas Characterization

Evaluation of the Wanapum Dam Fish Bypass (WFB) 2008

Outline

- Wanapum Dam Fish Bypass
- Regulatory Requirements
- TDG Evaluation
  - Objectives
  - Methods
  - Results
- Conclusions

Wanapum Dam


N
0
50
100
150
200
Meters
Spillway
Future Units
Powerhouse
Fish Bypass

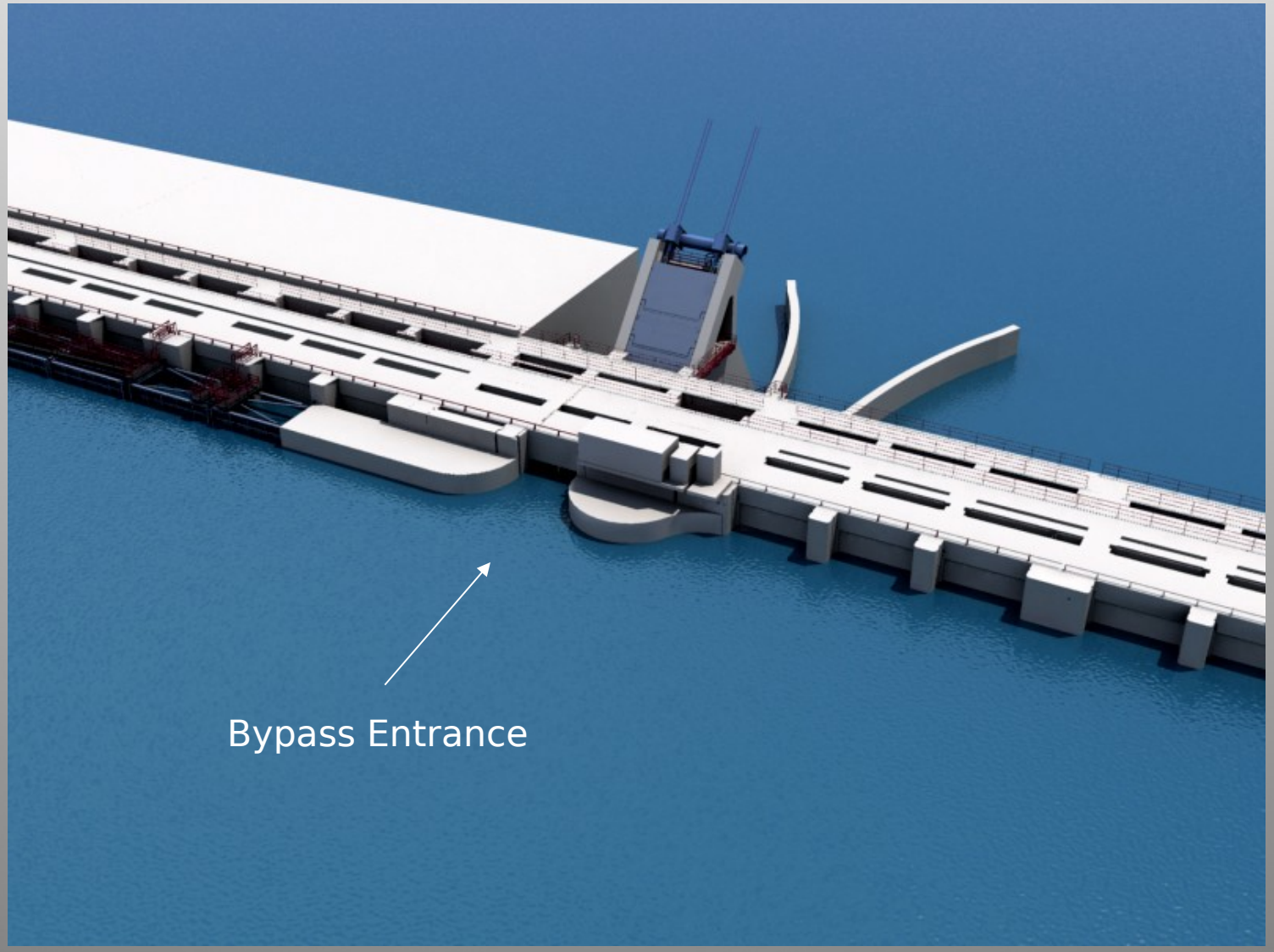
WFB - Objectives

- Biological Opinion Requirements
- 95% Juvenile Salmon Survival
- Reduce Spill
- Reduce Total Dissolved Gas

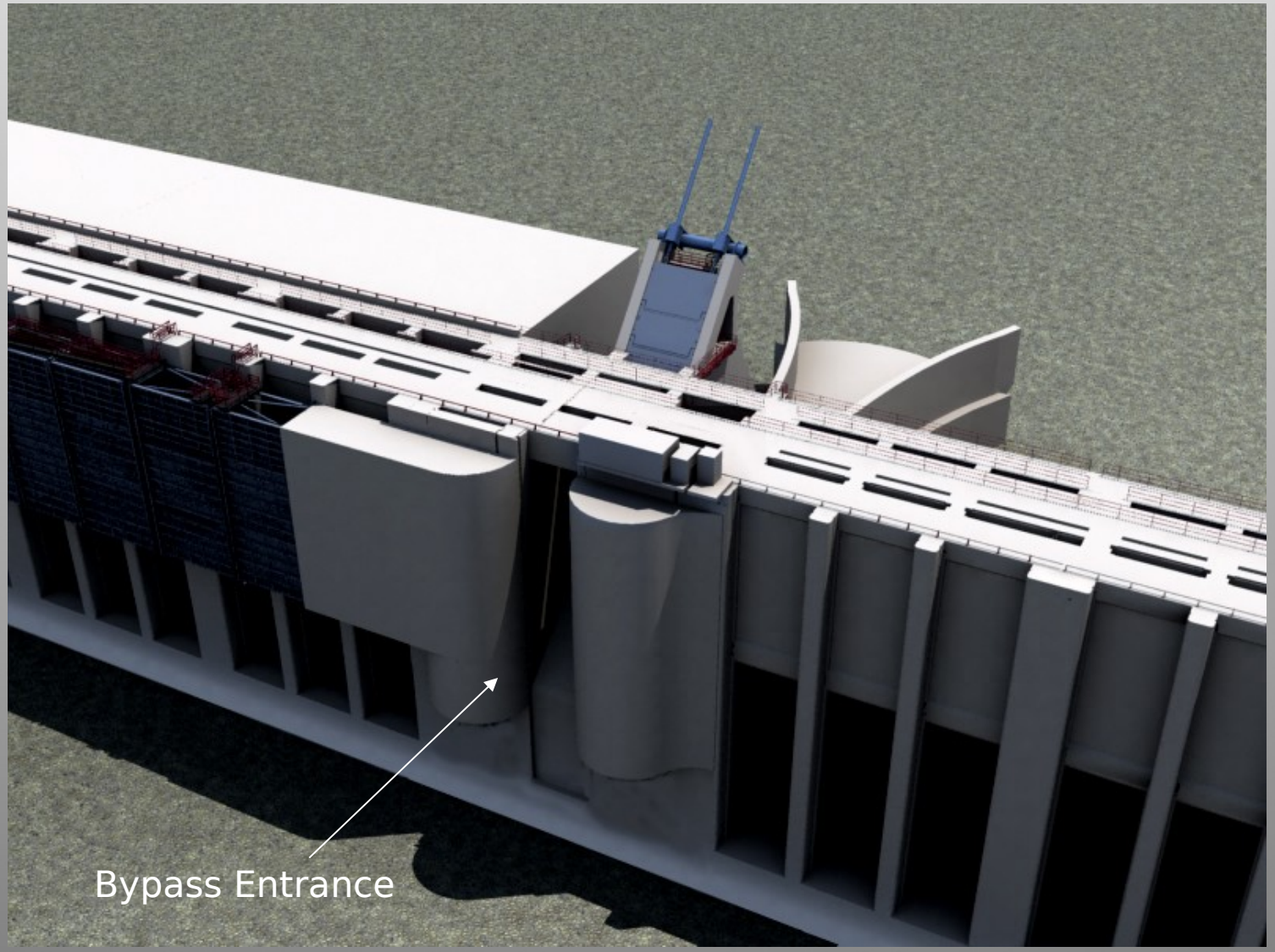
WFB - Features

- Nominal full bypass flow of 20,000 cfs
- Vertical and inclined gates to set lower flow rates (15 kcfs, 10 kcfs, 5 kcfs and Sluice)
- Finished opening through concrete is 18.5 feet wide
- Length of 290 feet upstream/downstream
- Exit chute width of 90 feet
- Discharge flow spread and elevated to minimize total dissolved gas (TDG) and tailrace scour

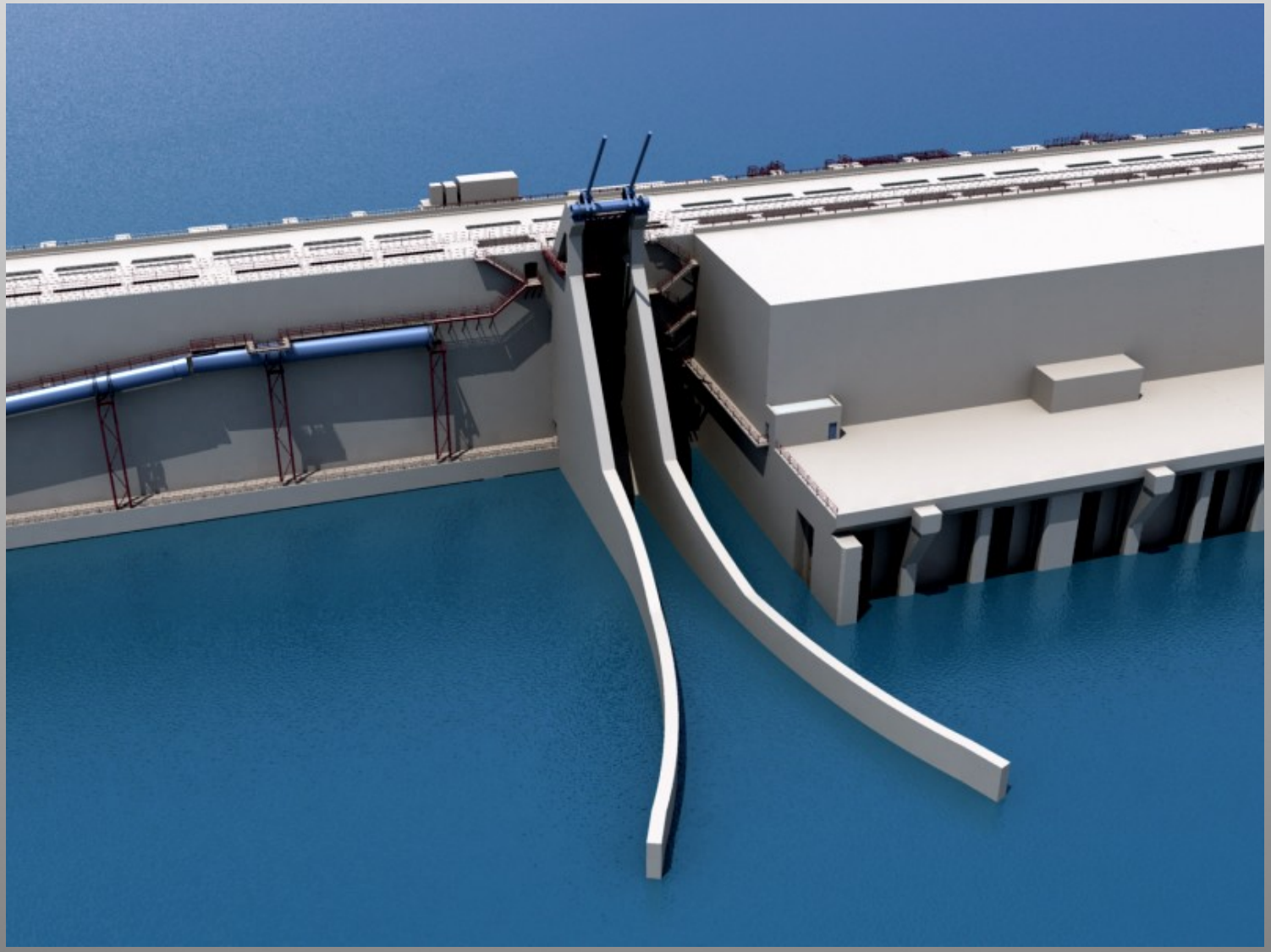
WFB – Upstream View



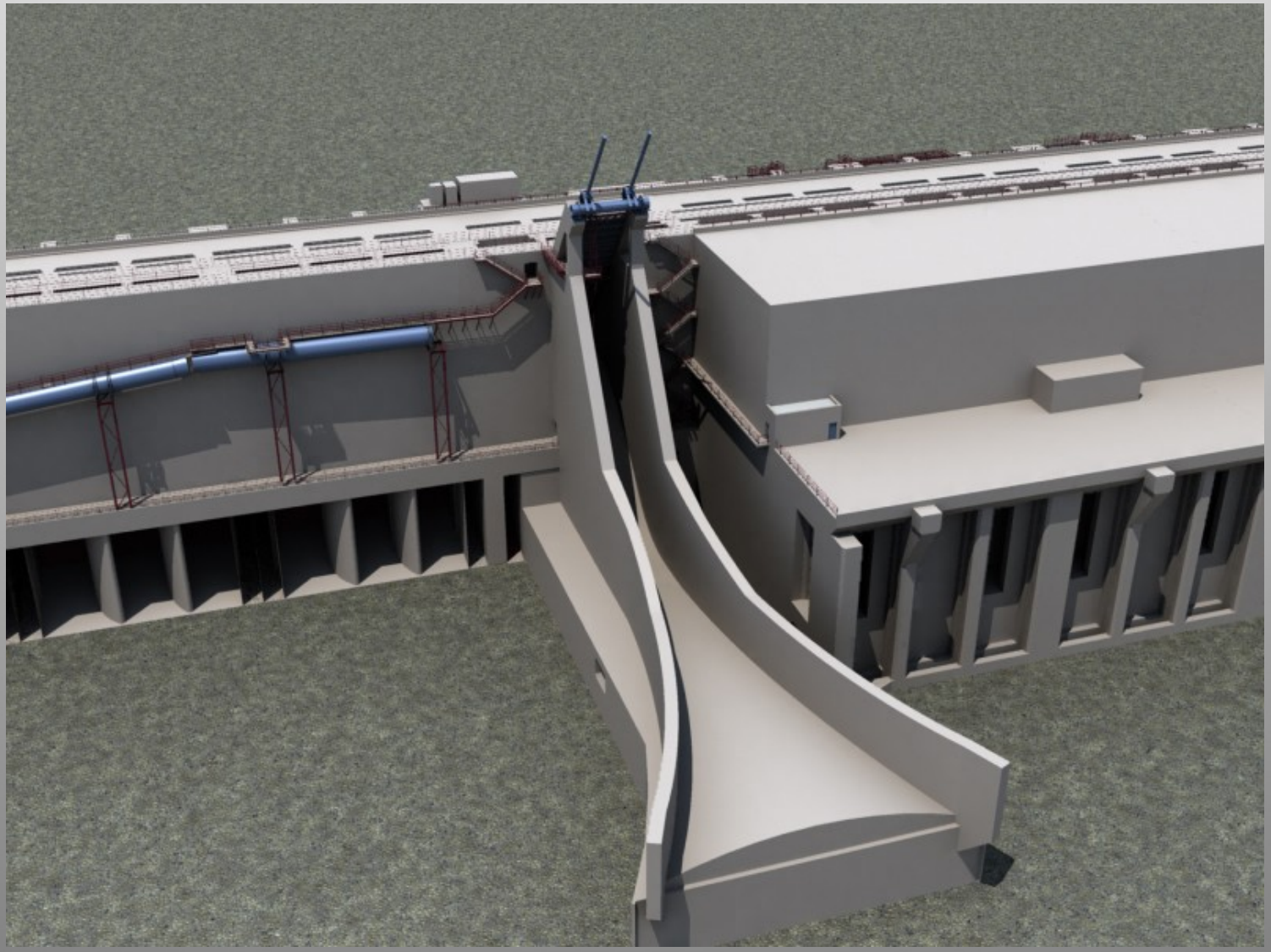
WFB – Upstream View



WFB – Downstream View



WFB – Downstream View



WFB TDG Field Study: Objectives

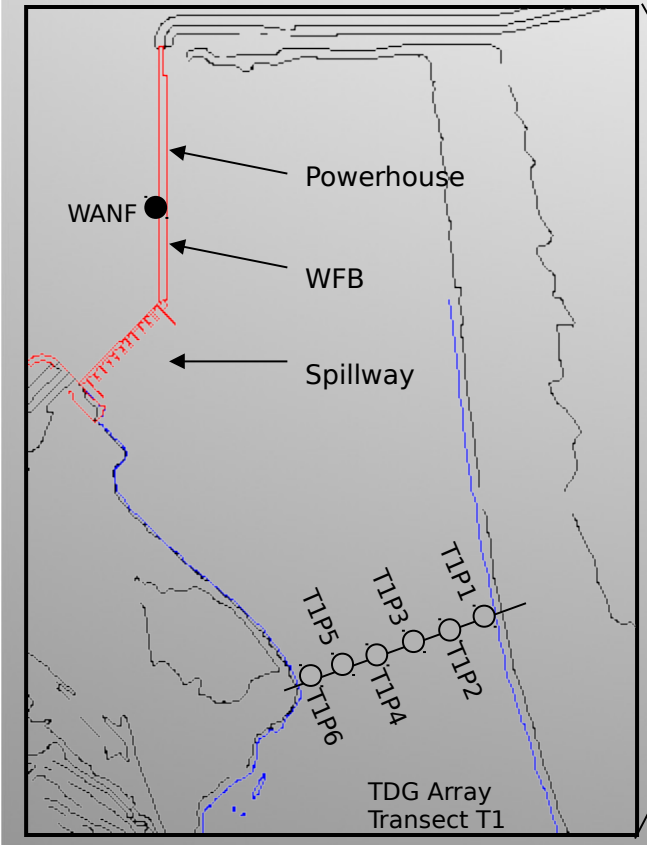
- The primary objective of the study is to quantify the TDG associated with the WFB operation under varying flow and tailwater conditions

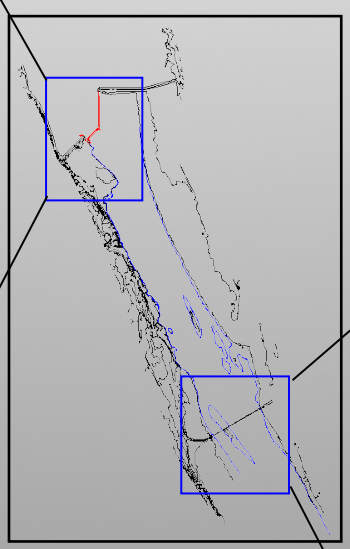
- A secondary objective of the study is to compare resulting TDG pressures at the tailwater transect (2000 ft downstream) to those measured at the tailwater fixed monitor location at Beverly Bridge (17000 ft) downstream

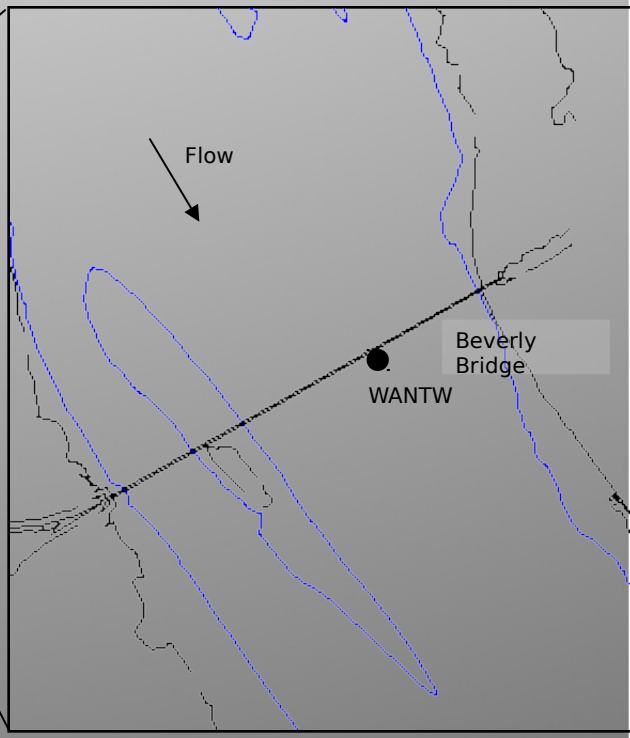
WFB TDG Field Study: Summary

- Study Duration: July 26 – Aug. 24, 2008 (29 days)
- WFB Flows: 19 – 20 kcfs
- Powerhouse Flows: 0 – 140 kcfs.
- Forebay elevations: 564.6 – 571.7 ft msl
- Tailwater elevations: 484.5 – 495.0 ft msl
- Spillway (Tainter-gate) operation occurred for a few hours on August 9th then again at the end of the study on August 22nd, 23rd, and 24th.
- (Retrospective Review of entire spill season using just tailwater monitor data during WFB operation)

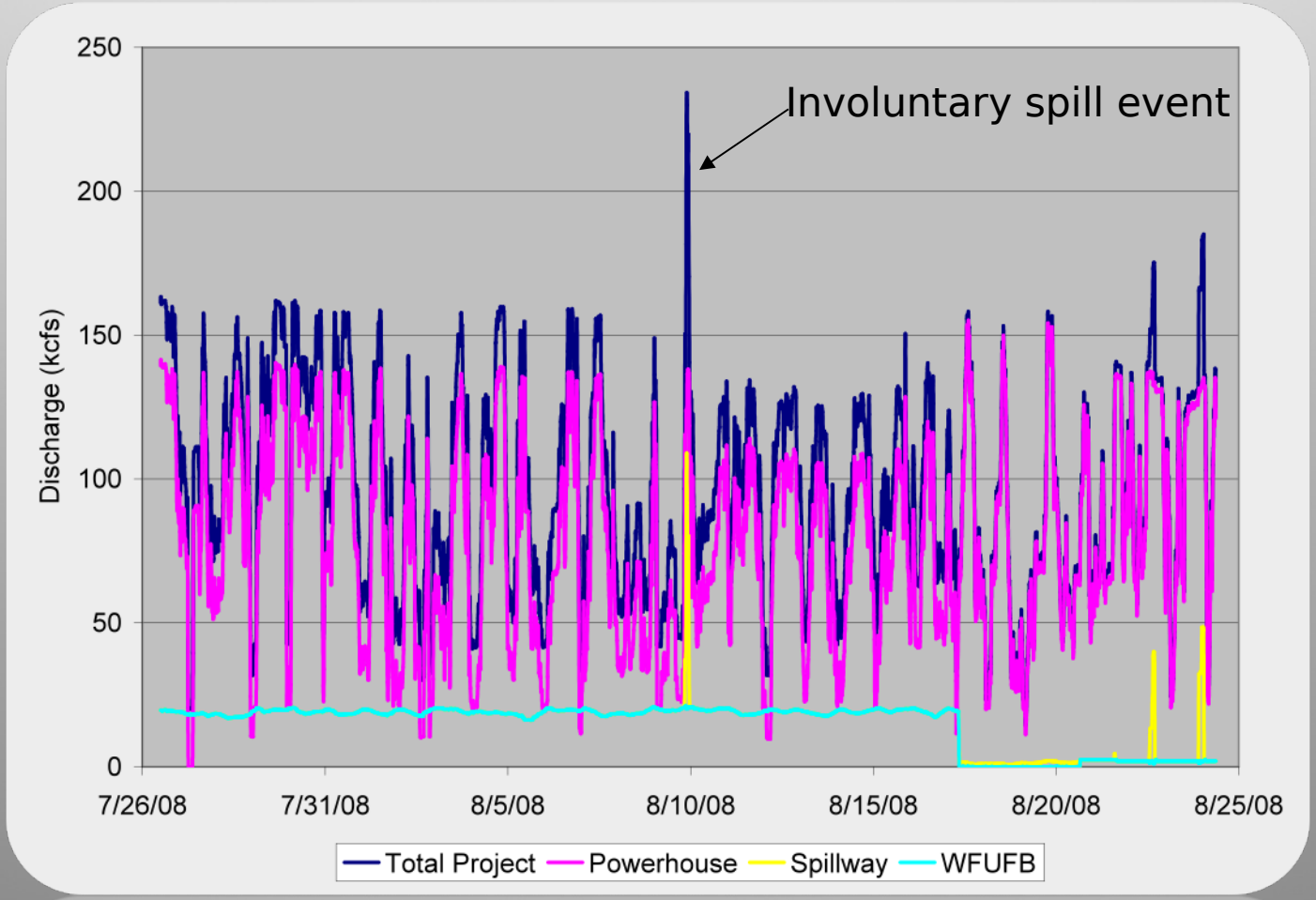
Location of WANF, Transect T1, and WANT



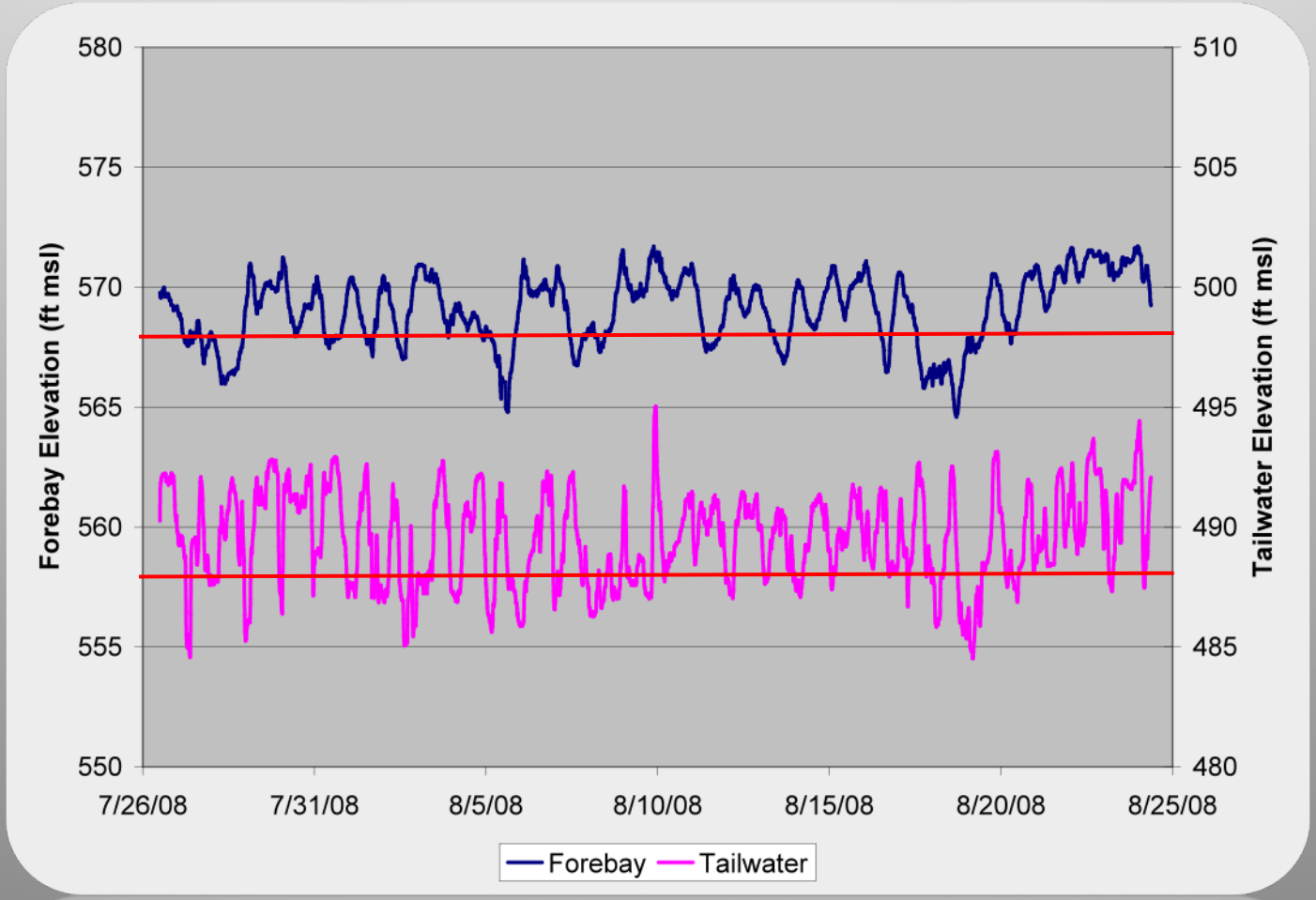




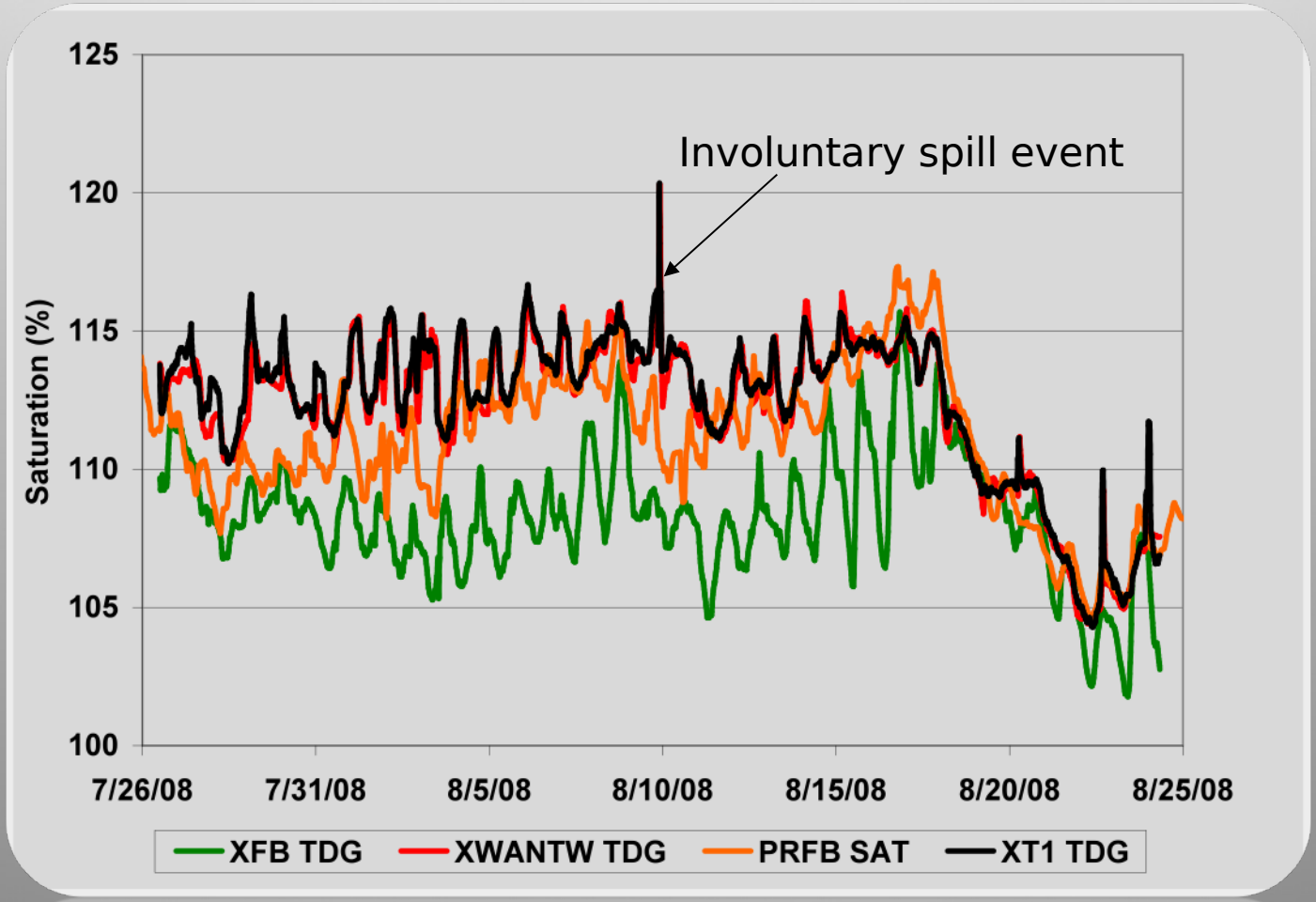
Wanapum Dam operations
July 26 through August 24, 2008



Wanapum Dam Forebay and Tailwater Elevation
July 26 through August 24, 2008



Wanapum Dam Forebay, Tailwater, and Priest Rapids Forebay Fixed Monitor TDG



WFB TDG Field Study: Objectives

- The primary objective of the study is to quantify the TDG associated with the WFB operation under varying flow and tailwater conditions

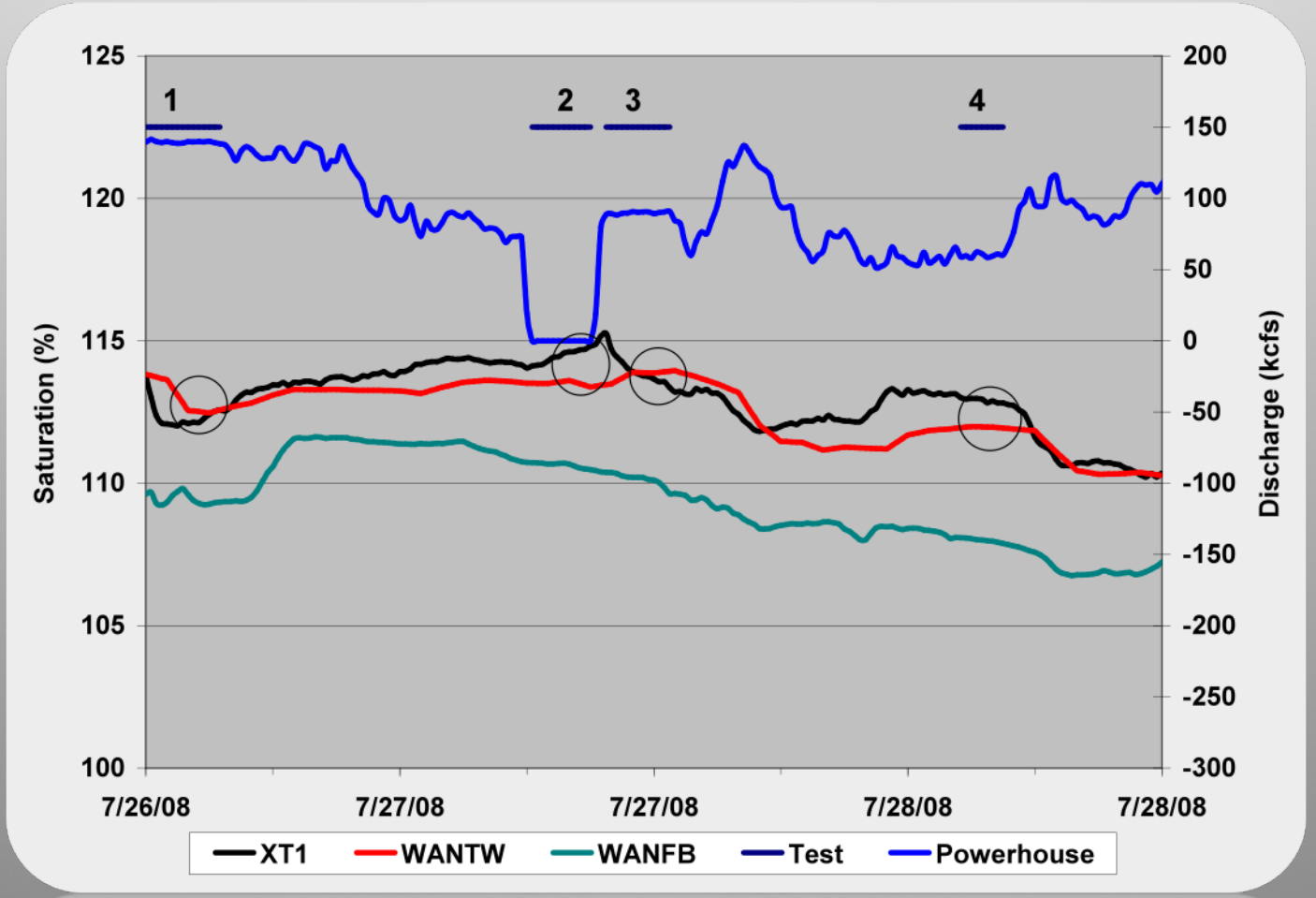
Targeted Operating Conditions

- Four targeted operating conditions in order to isolate TDG exchange under varying tailwater conditions:
  - no flow (3 events at 0-10 kcfs)
  - 60 kcfs (6 events at 50-72 kcfs)
  - 100-120 kcfs (11 events)
  - and greater than 140 kcfs (5 events at 130-140 kcfs)
- Each targeted operating condition was to be held steady long enough to allow conditions to stabilize in the tailrace.
- Numerous times with constant conditions occurred for 2 hours or greater incidentally .
- 53 periods were identified meeting the operating requirements of a test
  - 44 occurred during the test operation of the WFB and 22 of these were at least a 3 to 4 hour period.
  - 25 targeted flows and 19 incidental test flows
  - 9 tests were identified during the period following the shutdown or minimum operation of the WFB, 6 of these lasted for a minimum of 3 hours

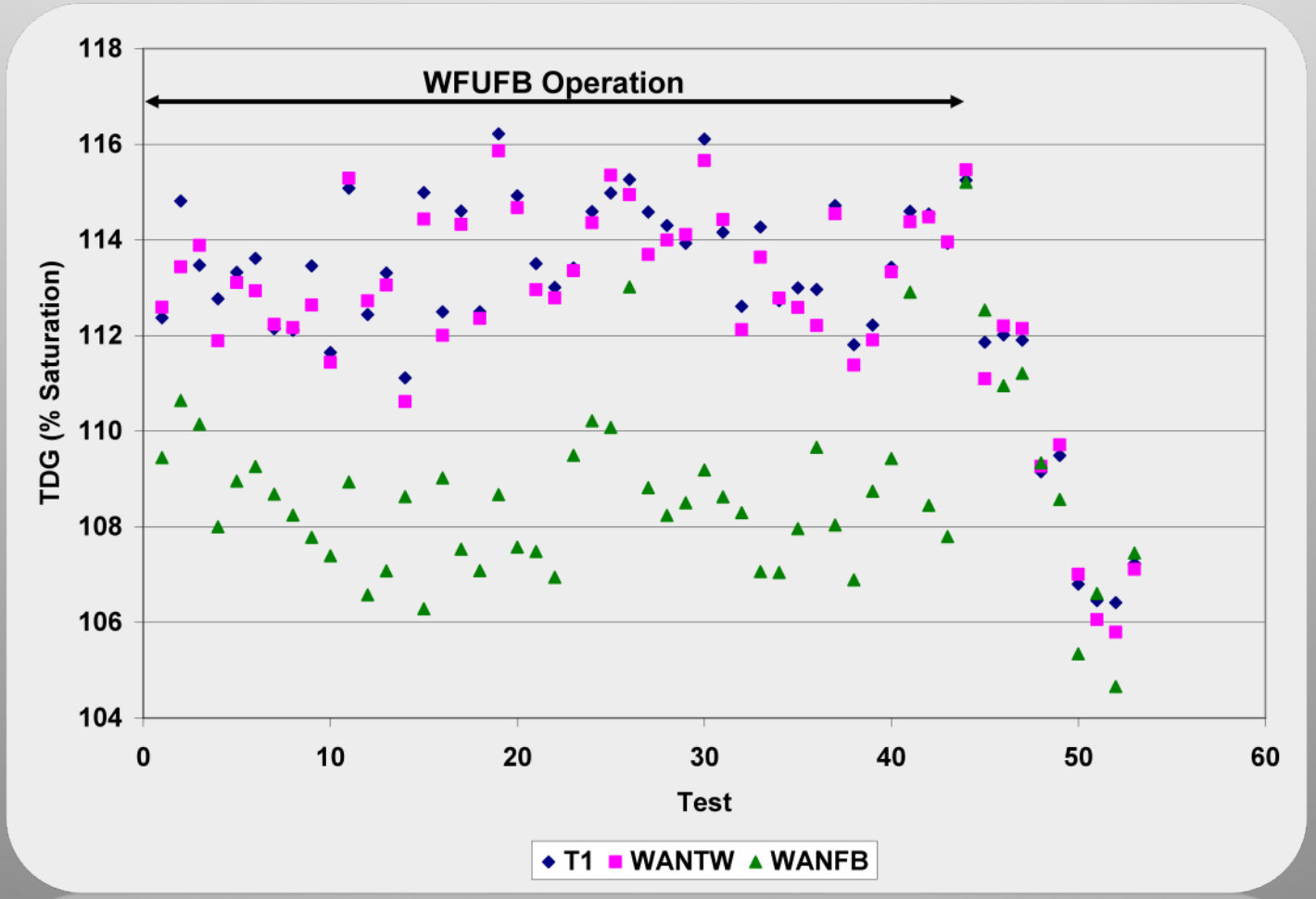
Determination of TDG by Test and for Each Station

- Average conditions were determined for each test identified
- Average forebay TDG and operations were calculated from the beginning to end of each test
- Average TDG for a test was determined from data representing near steady state conditions based on a time lag for a station or distance downstream
- A time lag was determined using visual observations of data time histories and average velocities and travel times as determined from numerical model results
- The time lag for stations on T1 was 2 hours after initiation of a test and then continued for 30 minutes beyond the end of steady operating conditions
- The time lag for the tailwater fixed monitor station was set at 2.5 hours following test start and continued until 1 hour following the test end
- Resulted in 3 to 18 data points for use in calculating the test statistics

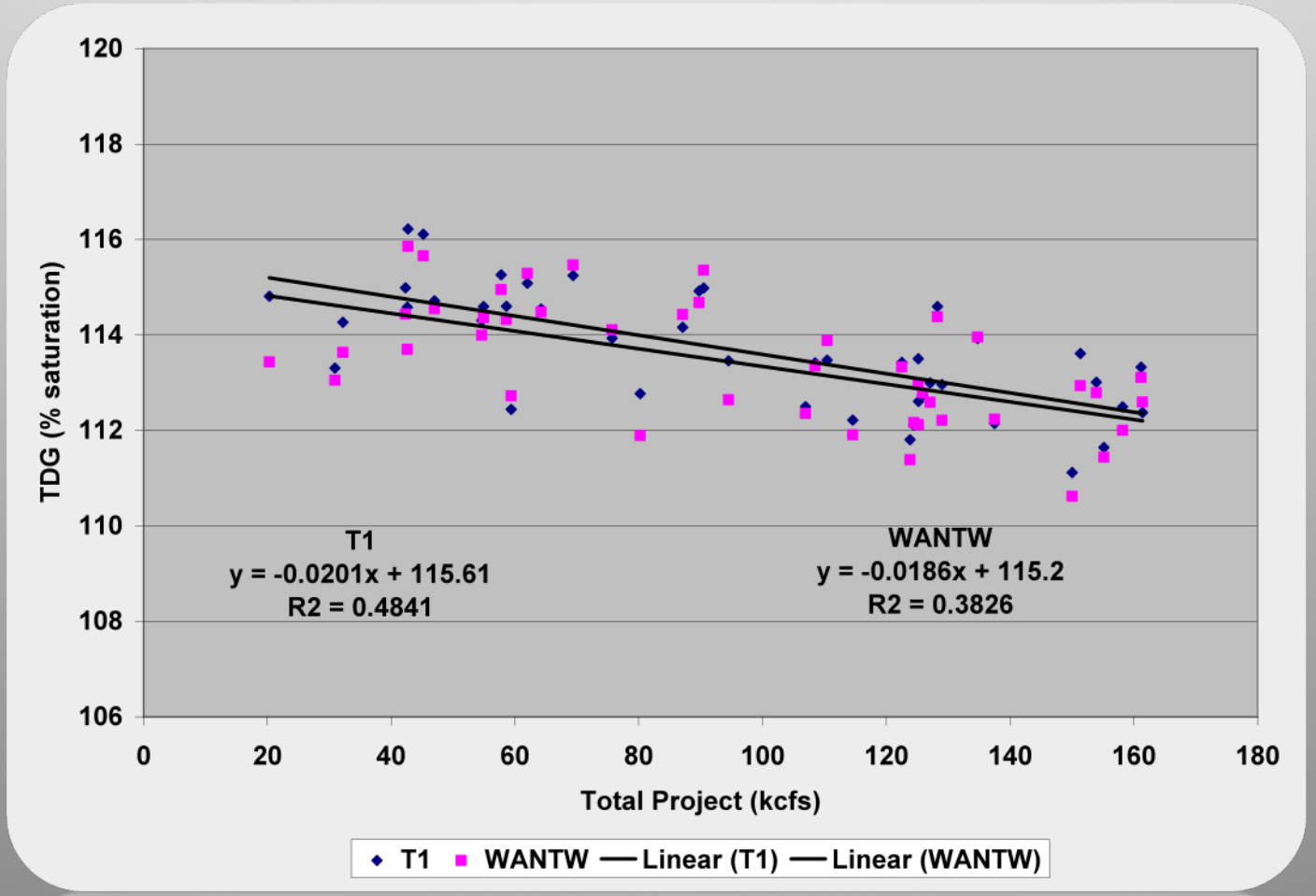
TDG Time Histories for Tests 1-4,7/26-7/28



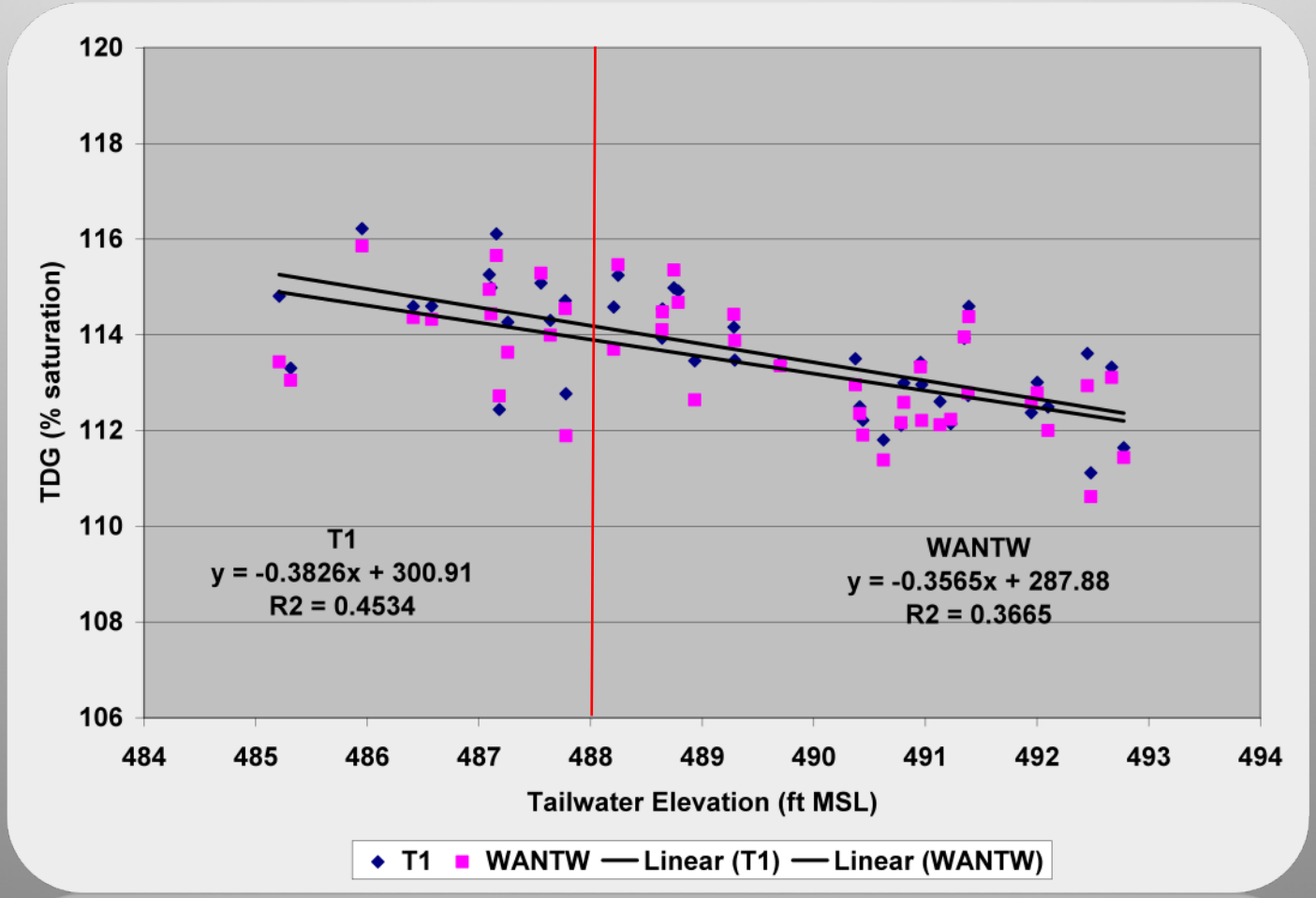
Average TDG for Test Periods



TDG vs. Total Project Discharge



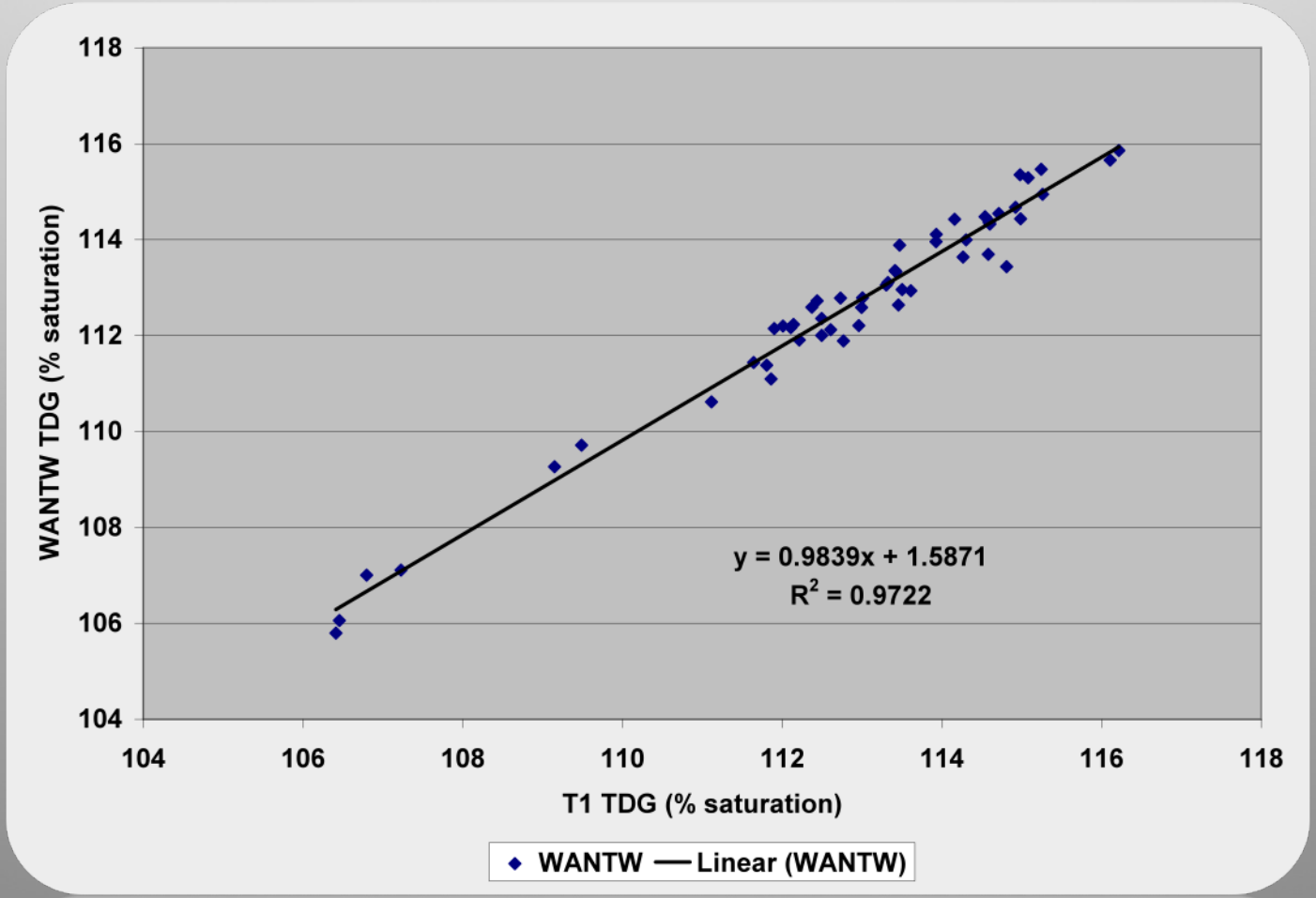
Tailwater Elevation vs TDG



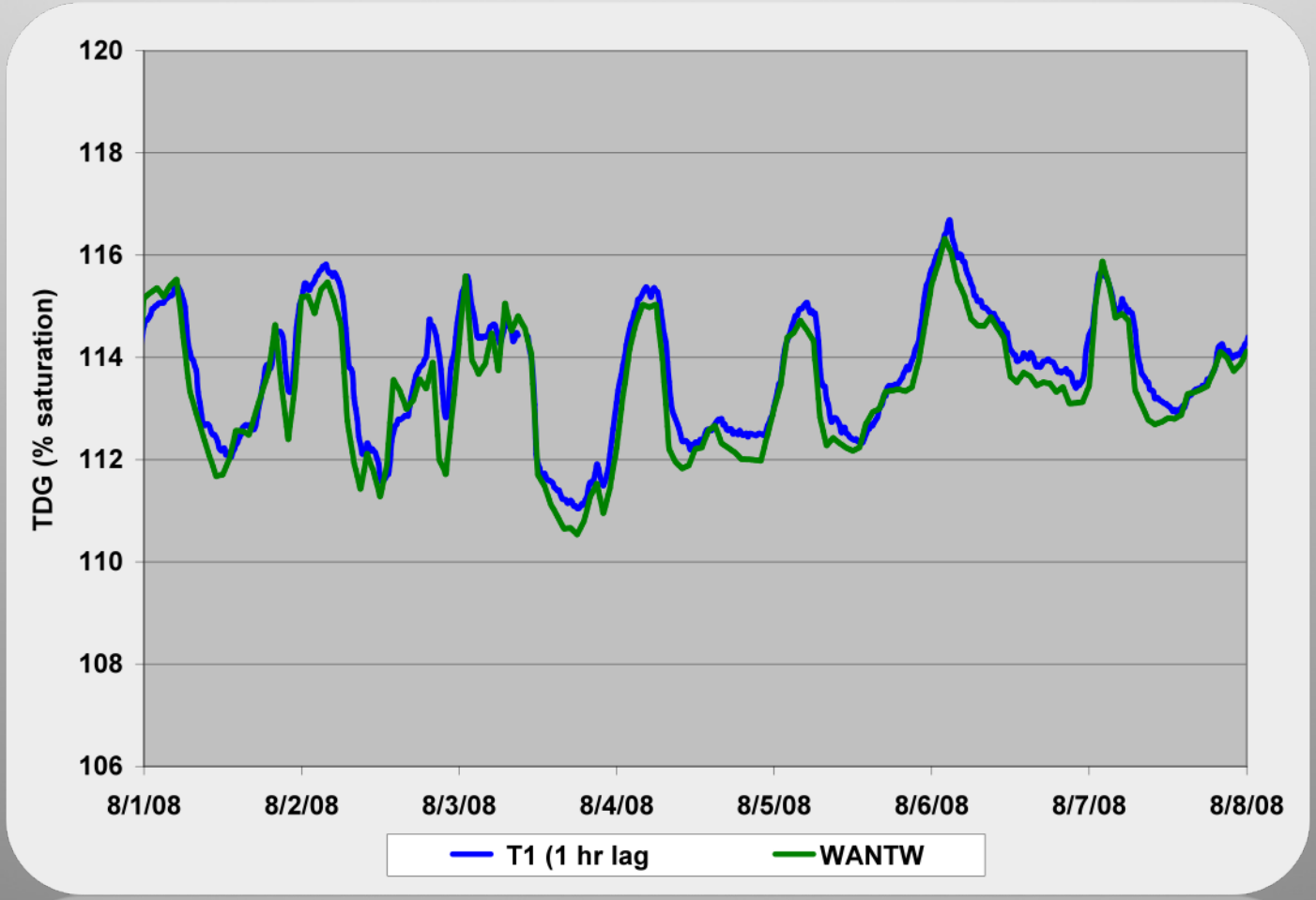
WFB TDG Field Study: Objectives

- A secondary objective of the study is to compare resulting TDG pressures at the tailwater transect (2000 ft downstream) to those measured at the tailwater fixed monitor location at Beverly Bridge (17000 ft) downstream

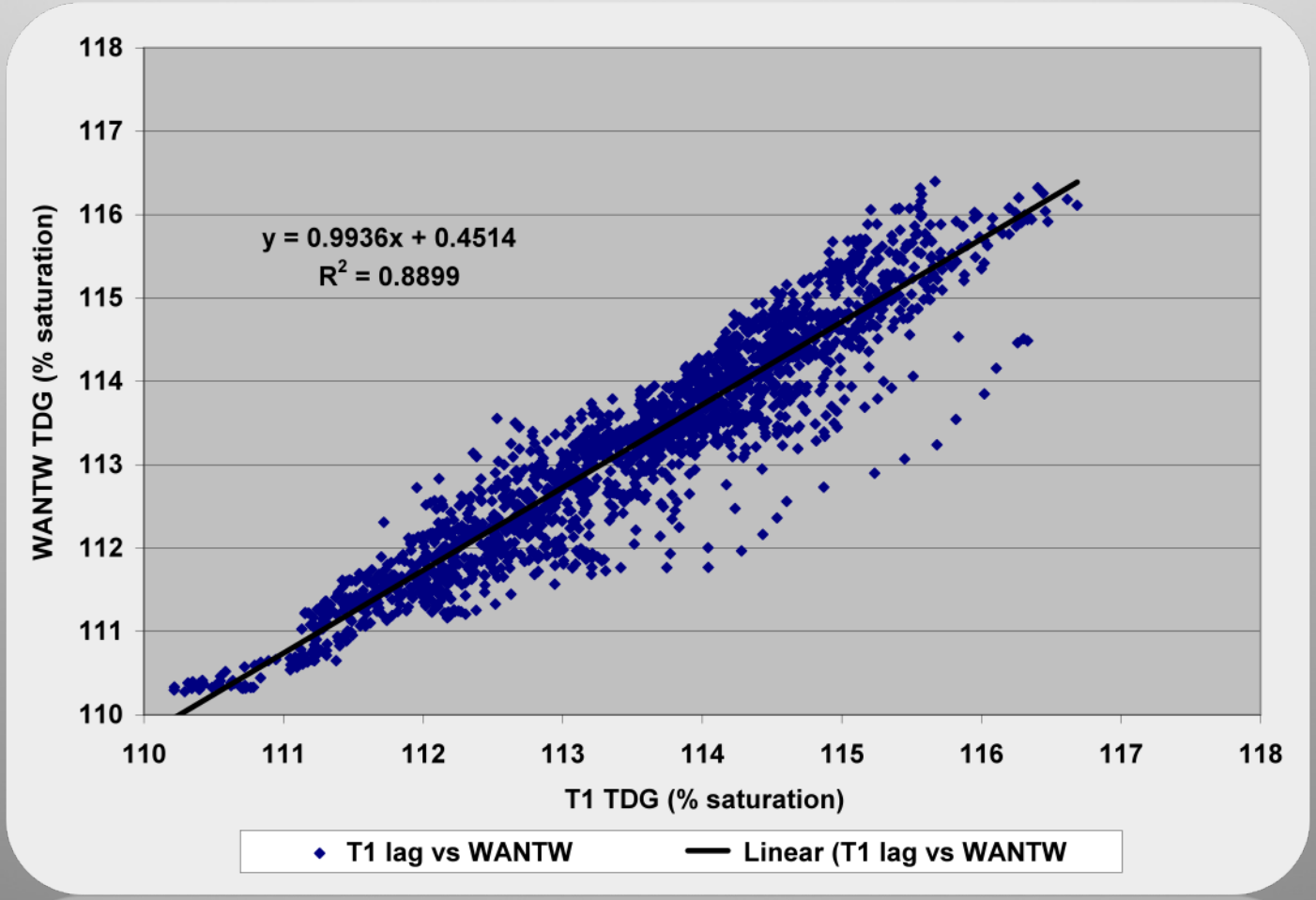
WANTW TDG vs T1 TDG



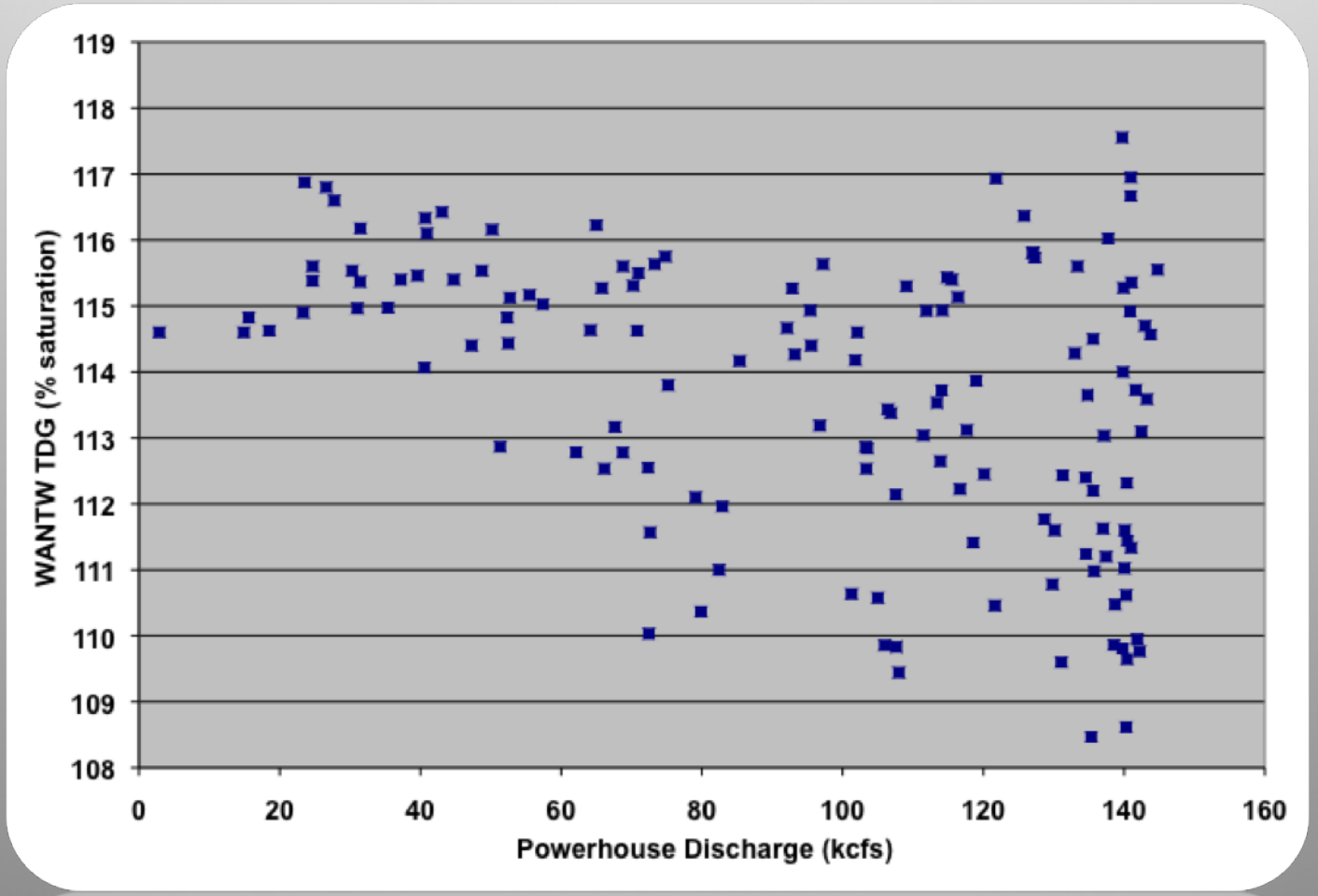
T1 TDG (lagged 1 hr) and WANTW TDG



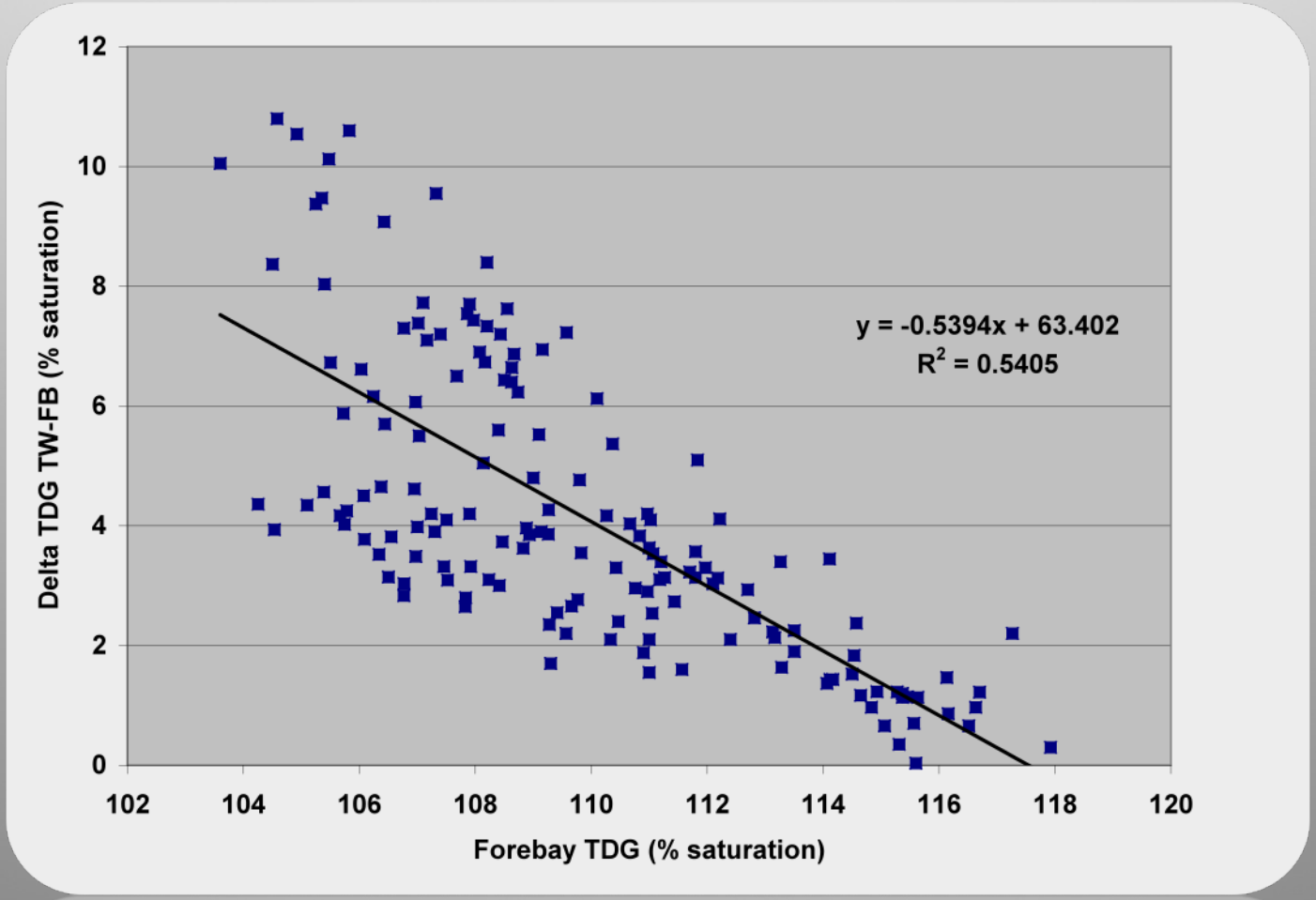
T1 TDG (lagged 1 hr) vs. WANTW TDG for period of WFB Operation



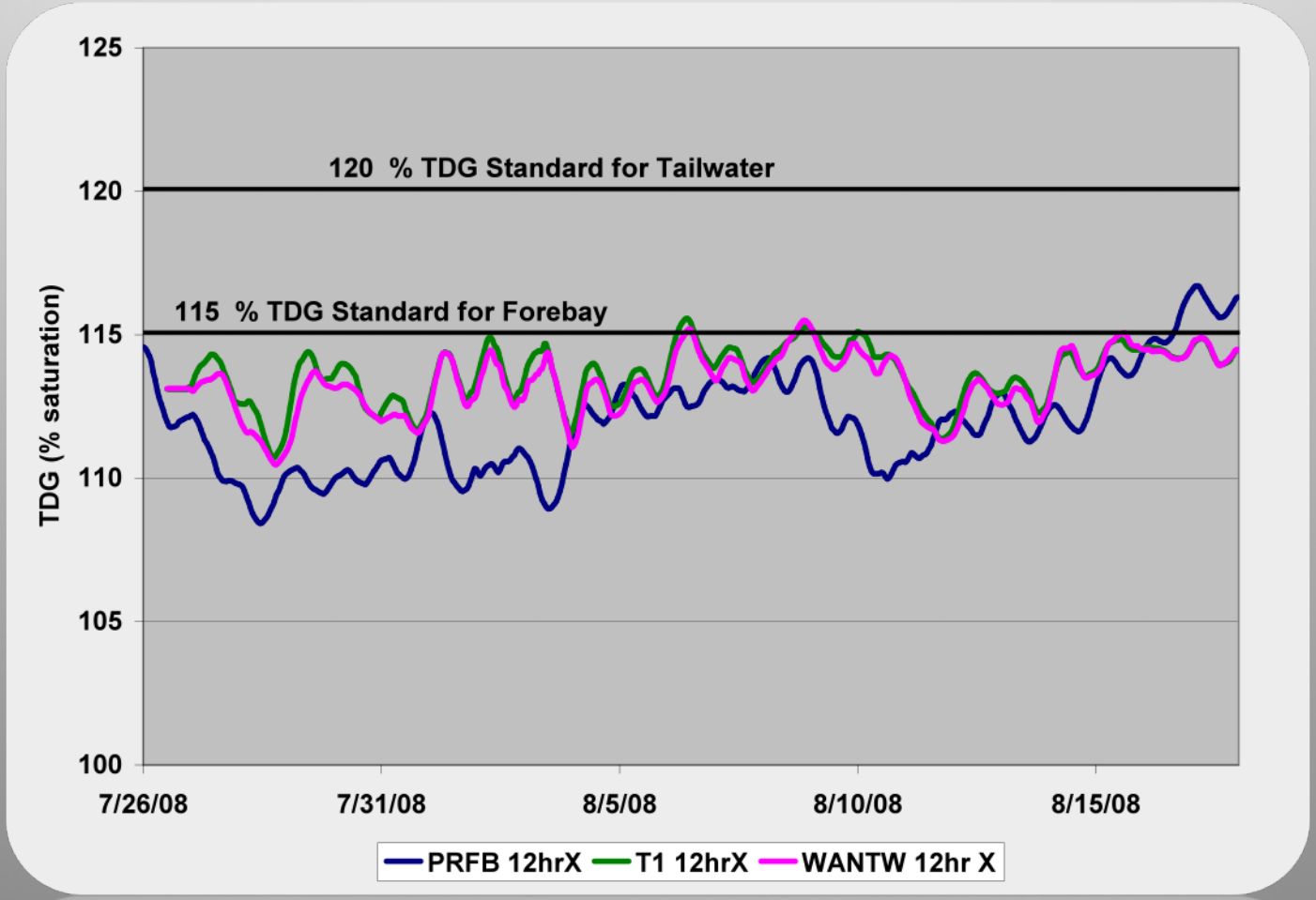
WANTW TDG vs. Powerhouse Discharge -Entire Spill Season-



Delta TDG (WANTW) vs. Forebay TDG -Entire Spill Season-



12 hr running average TDG for T1, WANTW, PRFB



WFB TDG Field Study: Observations

- Primary study objective - quantify the TDG associated with the WFB channel chute operation
  - Resulting TDG in downstream reach varied from 111 % up to 116 % saturation for the field test periods when the WFB was in operation at 18-20 kcfs and the powerhouse was discharging between 0 and 140 kcfs total. The mean TDG over all tests was 113.7 % (sd=1.3)
  - Retrospective data analysis for the 2008 spill season peaked at 118% TDG for periods of WFB operation
  - Running 12-hr averages were less than 116% for WFB operation
  - Downstream TDG decreased with increasing powerhouse discharge, ~3 % over the range of discharge with similar results from comparison with tailwater elevation
  - The Wanapum tailwater and Priest Rapids forebay TDG standards were met during entire operation of WFB in 2008 (AND during 2009)
  - Minimal vertical or lateral gradients were observed in TDG or temperature at T1. TDG was generally uniform across transect T1 during the study with a modest 1% lateral gradient. This gradient varied depending on the amount of powerhouse operation.

WFB TDG Field Study: Observations

- Secondary study objective - compare resulting TDG pressures at the tailwater transect (2000 ft downstream) to those measured at the tailwater fixed monitor location at Beverly Bridge (17000 ft) downstream
  - Very little change resulted in TDG from the Transect T1 down to the fixed monitor location at Beverly Bridge. Tailwater monitor vs T1 TDG relationship was essentially 1 to 1 with an R^2 of 0.97. Mean difference was 0.2 % (sd=0.4) generally fell within the T1 lateral gradient range indicating only a minor longitudinal gradient downstream of the 2000 ft reach.

WFB TDG Field Study: Conclusions

- Objective 1: Based on the summer Field Study coupled with the Retrospective analysis of 2008 operations of the WFB between 15 and 21 kcfs the peak downstream TDG will remain below 118% saturation. This applies to the full range of project turbine operations as well as a full range of forebay TDG levels.

- Objective 2: The existing tailwater TDG monitor at Beverly Bridge 3.2 miles below Wanapum Dam is minimally different, 0.2%, from the average TDG measures taken at 2000 ft below the dam during the WFB operation.

Questions?